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THE FREE ATMOSPHERE IN INDIA<sup>1</sup>(Reprinted from *Nature*, 114, No. 2864, September 20, 1924)

The memoirs before us are by Mr. J. H. Field, who has succeeded Sir Gilbert Walker at Simla, and by Dr. W. A. Harwood. They are of particular interest from the fact that both authors have been connected with upper-air work in England almost from its first conception.

In the introduction, Mr. Field discusses the methods and instruments that were used, many of which were designed by him especially for the purpose; and he is to be congratulated on the success that has been attained.

Owing to the climate of India the ordinary rubber balloons could not be used, on account of the difficulty of storage, and gutta-percha balloons, made up as required, were substituted for them. Mr. Field describes his semigraphical methods of working up theodolite observations quickly, and gives some very useful formulæ showing the final error in terms of the errors of observation. He finds that too much trust may easily be placed in the two-theodolite method, and gives an example in which the four angular measurements are perfectly consistent among themselves and yet the height of the balloon is in error by 50 per cent. He adopted the tail method for general use.

The results of some very useful experiments are given, showing the extent of the errors which may occur owing to the heating by solar radiation of the recording instruments, and also by the inevitable lag of the thermograph. The conclusion reached is that the resulting error is small up to a height of 6 kilometers, and this is confirmed by the good agreement of the mean values obtained by night and by day. Above 10 kilometers the error is increased by the unfortunate necessity in having to use gutta-percha balloons, the rising velocity of which falls off as their highest point is reached; but up to 12 kilometers it does not seem likely that the error exceeds two or three degrees.

In Part VI, Doctor Harwood discusses the observations made with kites and registering balloons over India and the Arabian Sea. He gives first a summary of the results obtained by Field by means of kites, and then deals with the registering-balloon ascents made in India, chiefly at Agra, during the years 1914-1918. In all 237 were sent up, 156 instruments were returned, and 152 of these gave usable records. \* \* \*

Doctor Harwood has taken every care to insure accuracy, and being well acquainted with the many possible sources of error, has only used such ascents as may be reasonably supposed to be free from error, especially from the effects of solar radiation, a precaution needful in view of the slow rise of gutta-percha balloons. He gives particulars of the temperature, humidity, and pressure at various heights in the three Indian seasons—the cool, the hot, and in the monsoon—and also annual means for the density. He carries his tables up to 12 kilometers, and it is only to be regretted that the stratosphere was not reached, and that at least the results from Agra are not published in full detail.

It is not possible to comment on the many interesting points discussed, but the following may be mentioned. The mean annual lapse rate comes out as identical up to 9 kilometers with that of nearly all other stations; so also the daily temperature variation in India, as elsewhere, is confined to the first 1 or 2 kilometers. The excessive heat of the hot season is found to be confined to the bottom layer; higher up the monsoon season is the hottest. The high correlation between pressure and temperature so noticeable in Europe is absent in India, perhaps because the short period variations of pressure are too small.

Comment is made on the figures for the Equator given by the reviewer in the *M. O. Geophysical Memoir*, No. 13, and the absence of information as to their source. These figures were formed from the smoothed mean values derived from the few data available at that time. Further observations on the Equator are necessary to show whether van Bemmelen's excellent set of results from Batavia, most of which have been published since then, fairly represent the general equatorial conditions.

Parts VII and VIII discuss the motion of the free air over India as it is observed by means of clouds and pilot balloons. The year is divided into three seasons, and three separate heights are taken—the height of low clouds, 2 kilometers; of middle clouds, 5 kilometers; and of high clouds, 9 kilometers. These are the heights assigned to the different clouds in the *International Cloud Atlas*, and Doctor Harwood accepts them as correct for India. Many tables are given showing the direction of the wind and the percentage frequencies for each direction at each height for 15 stations distributed over the peninsula; in some cases separate values for each month are given. It is noted that cloud observations necessarily refer to cloudy weather and that pilot-balloon observations will refer chiefly to clear weather, and there is some evidence that there is a systematic difference between the two, but it does not seem to be large enough seriously to prejudice the results of using them as equivalent. The figures will be of great interest to anyone who is endeavoring to elucidate the cause of the monsoons.

In Part VIII the relation of the monsoons to the general circulation of the atmosphere is dealt with, and the similarity of the northeast monsoons to the circulation over the North Atlantic is discussed. Doctor Harwood finds a very noticeable coincidence between the track of storms and depressions, as shown in the *Climatological Atlas of India* and in the *Meteorological Atlas of the Indian Sea*, and the monthly mean directions of the upper winds at the cirrus level. If this be more than a coincidence, and it seems to be so, it has an important bearing on the formation and propagation of cyclones, and shows that their source must be sought for in the upper winds rather than in the surface conditions.

The four Memoirs form a very valuable contribution, not to Indian meteorology only, but also to meteorology in general.—*W. H. Dines.*

<sup>1</sup> "Memoirs of the Indian Meteorological Department." Vol. xxiv., Parts v, vi, vii, and viii.